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(54) Method of washing off magnetically separated particles.

(57) A method of removing magnetically-separated magnetic particles adhering to a magnetic filter. Sets of radially-arranged magnets are provided above and below, with adjacent magnets having unlike poles. The filter is located in an alternating magnetic field formed by the magnets. The filter is washed by directing a jet of fluid at it while magnets, or filter, is being rotated.

FIG. 2

(A)

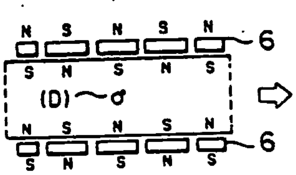
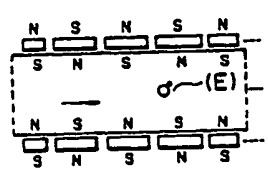


FIG. 2

(B)



EP 0 318 913 A2

Method of washing off magnetically separated particles

This invention relates to a method of washing filters that continuously remove magnetic particles, produced by metal processing or wear, that are present in water and in the atmosphere, microorganisms accompanying magnetism and magnetic particles entrained in fluids.

Magnetic separators employing permanent magnets and electromagnetic or permanent magnetic filters employing ferromagnetic fibers or beads are conventionally used to remove magnetic particles and microorganisms accompanying magnetism entrained in fluids (hereinafter the removal of magnetic particles and the like adhering to electromagnetic filters will also be referred to as "washing").

However, magnetic separators have a poor performance and provide insufficient washing. Electromagnetic filters, on the other hand, have superior magnetic-particle-removal performance but it is necessary to clean the filters effectively. In JP-A-54(1979)-86878, for example, in which a ferroelectromagnet is used to set the magnetic field to zero, a large apparatus is required to free the filter from the magnetic field, involving a large consumption of electricity and a major outlay in manufacturing costs that make the cost-performance thereof unsatisfactory.

Washing water, hydraulic fluid, cooling water, process fluids and other such fluids used in product manufacturing processes in the steel industry, automotive pressed parts and processing industries, for example, contain large quantities of magnetic particles entrained therein. As well as reducing the surface cleanliness of the products, this has a major effect on product quality, producing blemishes and the like, and also because of these magnetic particles, washing tanks and piping has become very costly.

In fresh-water and waterworks treatment facilities, too, the formation of rust, iron bacteria and the like from tanks and pipes is unavoidable and is a cause of scaled waste water and the like in the waterworks system. Large purification tanks and separation equipment are required to remove this at a huge cost.

Thus, for manufacturing industries, the efficient removal of magnetic particles in such fluids is beneficial in terms of product quality and equipment maintenance costs, and for water treatment facilities it also helps to reduce the equipment costs and to make the water supply safer. However, because such magnetic particles are so small, ordinary filters are quickly clogged, and the cost-performance of conventional magnetic separation apparatuses renders them unsuitable.

In the example of the steel-making industry, minute steel particles produced during the cold-rolling of steel sheet adhere to the sheet. The sheet is therefore subjected to a process to remove the particles, for example, an electric cleaning process, before it is sent on to be heat-treated, plated, and so forth.

Drum-type magnetic separators and cloth filters are generally used to reduce the amount of steel dust in the tanks of rolling oils and washing fluids. However, drum-type magnetic separators have a very low removal efficiency, because the magnetic particles are only held by the magnetic force in the vicinity of the surface of the drum. With cloth filters, too, the minute size of the steel particles makes the removal efficiency lower, in addition to which the filters quickly become clogged, involving large outlays for cloth.

Conventional apparatuses include electromagnetic filters that employ ferromagnetic small-gage wire. Utilizing the principle of high-gradient magnetic separation, a large magnetic gradient is generated around the ferromagnetic small-gage wires to effect separation of the magnetic particles with good efficiency. However, with current constructions it is difficult to clean the filters. In the cleaning process huge electromagnetic coils are used to control the magnetic field, so the cleaning involves the use of a large apparatus, major fabrication expenditures and the consumption of enormous amounts of electricity. Therefore the major problem is how to remove the magnetic particles adhering to the filters economically and efficiently.

There are apparatuses that combine the low cost of the magnetic separator with the high efficiency of the electromagnetic filter, but the washing efficiency of such apparatuses is poor and the high efficiency cannot be maintained over a long period.

SUMMARY OF THE INVENTION

The object of the present invention is to provide a method of cleaning magnetic filters by efficiently removing magnetically separated particles adhering to the magnetic filters.

Another object of the present invention is to provide a method of washing a magnetic filter using centrifugal force, and pulsed washing and an alternating magnetic field.

BRIEF DESCRIPTION OF THE DRAWINGS

Figures 1(a) and 1(b) are explanatory drawings of the cleaning method according to the present invention;

Figure 2(A) is an explanatory drawing of the interior of the filter concerned; Figure 2(B) is an explanatory drawing showing when the filter is cleaned; Figure 2(C) is a graph of the alternating magnetic field; Figure 2(D) shows a part of the view shown in Figure 2(A); and Figure 2(E) shows a part of the view shown in Figure 2(B);

Figure 3(A) is an explanatory drawing showing the interior of another example of a filter; Figure 3(B) is an explanatory drawing showing an another example of when a filter is cleaned; Figure 3(C) is a graph of another example of an alternating magnetic field; and Figures 3(D) and 3(E) each shows part of the views shown in Figures 3(A) and 3(B) respectively;

Figure 4 is an explanatory drawing of the washing situation when washing fluid is supplied continuously (not intermittently);

Figure 5 is an explanatory drawing of an example of the apparatus used;

Figure 6 is an explanatory drawing of another example of the apparatus used;

Figure 7 is an explanatory drawing of the operation of another example of the invention;

Figure 8 is an explanatory drawing of another example of an apparatus for the method of the invention;

Figures 9 and 10 are curves showing the effect of implementing the method of the invention;

Figure 11 is an explanatory drawing showing a magnetic-particle magnetic separation system;

Figures 12 and 13 are explanatory drawings showing conventional filter washing methods.

DETAILED DESCRIPTION OF THE INVENTION

The magnetic-separation system for removing magnetic particles in a fluid will now be described briefly with reference to Figure 11.

Rolling oil used in a cold-rolling system 1, for example, contains magnetic particles produced during the cold rolling. The rolling oil is sent via a passage A_1 to a magnetic filter 2 where the magnetic particles are removed, after which the cleaned fluid is pumped into a circulation tank 3 via passage A_2, and after it has accumulated therein it is again used in the cold-rolling system 1.

In another system the rolling oil used in the cold-rolling system 1 is collected in the tank 3 via a passage A_3, and is passed along passages A_4 and A_2, in the course of which the fluid is cleaned by the magnetic filter 2.

Because in both of these fluid cleaning systems the particle-removal capability of the magnetic filter 2 deteriorates over time, the filter has to be cleaned periodically or in response to the deterioration in its particle-removal capability.

To wash the filter, the washing medium (water, steam, oil, etc.) is fed in via passage B_1 and the magnetic filter element is rotated at 300 to 3,000 rpm. The magnetic particles expelled thereby pass through passage B_2 and are collected in a discharge tank 5. By repeating this process, particles can be continuously removed from the rolling oil with good efficiency.

The present invention comprises expediently washing the filter by removing magnetic particles adhering to the magnetic filter following the use of the filter to remove the magnetic particles from the fluid. For this, the method of the invention comprises disposing magnets above and below the magnetic filter, and with these magnets fixed in place, rotating the magnetic filter to thereby effect the washing of the filter by the centrifugal force and alternating magnetic field thereby generated.

Namely, as shown by Figure 12, a magnetic filter 2 in general use is provided with magnets 6 arranged radially in the filter's plane of rotation and in the thickness direction of the filter. When the said magnetic filter 2 is rotated to utilize the centrifugal force thus generated to remove magnetic particles from the filter, the washing fluid applies a fluid drag on the particles that is greater than the magnetic force of the particles. The behavior of the washing fluid is shown in Figure 13. Namely, when the magnetic filter 2 is rotated the washing fluid describes a parabola, as shown by arrow a, as it tries to flow in the opposite direction to the rotation, but as it is obstructed by the magnets 6, in the latter half of its flow, as shown by arrow b, it moves along the magnets to form a stagnant area c, which is forms a non- cleaning area, and thus, magnetic particles in the filter are unable to be removed completely.

During the washing, when there is no fluctuation in the magnetic field in the filter, the centrifugal force acting on the particles, and the action of only the washing fluid the drag of which has been increased by the

centrifugal force, can be cited as causes of low washing efficiency.

In accordance with the present invention, as shown in Figure 1, a multiplicity of magnets 6 are disposed above and below the rotating surface of the magnetic filter 2. With the magnets arranged above and below in a mutually attractive formation and in an alternating-pole formation in the direction of filter rotation, the magnetic field thus formed perpendicularly to the direction of filter rotation and the multiplicity of magnetic fields in the direction of filter rotation produce an alternating magnetic field. Therefore, as shown in Figure 1(b), by having just the filter rotate in the alternating magnetic field, the alternating magnetic field is applied to the filter, enabling the magnetic particles to be removed with good washing efficiency.

The washing effect according to this invention is shown in Figure 2. When the ferromagnetic small-gage wires constituting the filter have the same magnetic characteristics as the magnetic particles to be removed, during filtration, as shown by Figure 2(A) 2(D), the particles are adhering to the ferromagnetic wire, a situation which is shown by state (a) in Figure 3(C). As shown by Figure 2(B) and 2(E), at the start of the washing, there is a chance to degauss the ferromagnetic wires together with the magnetic particles, by an amount proportional to the rate at which the generated alternating magnetic field revolves. As a result, it becomes easy to separate the particles from the wires, and cleaning of the filter can be facilitated by the centrifugal force acting on the particles and the increase in the fluid drag produced by the centrifugal force. In this case, the particles degauss at state (b) in Figure 2(C).

Figure 3 illustrates the effect of the invention when the ferromagnetic small-gage wires and the magnetic particles to be removed have different magnetic characteristics. During filtration, as shown by Figure 3(A) and 3(D), the magnetic particles are adhering to the ferromagnetic wires, a situation that is shown by state (a) in Figure 3(C). As shown in Figures 3(B) and 3(E), at the start of the cleaning, by as much as the amount of the revolving of the alternating magnetic field generated there is a chance to separate the particles from the wires when the two repel each other. As a result, cleaning of the filter can be facilitated by the centrifugal force acting on the particles and the increase in the fluid drag produced by the centrifugal force. This situation is shown by state (b) in Figure 3(C).

As shown in Figure 4, when the washing fluid is supplied to the filter in a continuous flow, the particles are removed in channels. The subsequent inflow of washing fluid flows into the channel offering the least resistance to the flow, preventing any improvement in washing efficiency. In the drawing, D_0 indicates a channel with lower particle density and D_1 the area with a higher particle density; the arrow a shows the direction of the flow of washing fluid.

When washing fluid is thus supplied intermittently, rotating the filter when the fluid is not jetting out even when channels have formed will close the channels, so that the next spurt of fluid will provide an effective washing action.

Figure 5 shows an example of an apparatus used in the invention.

Fluid containing magnetic particles to be filtered provided by a pump 8 enters the magnetic filter 2 and is passed through a magnetic field formed by permanent magnets 6 disposed above and below the filter. In the course of this, the large magnetic gradient generated by the ferromagnetic small-gage wires that constitute the filter cause the particles to be removed from the fluid to the wires. The fluid thus cleaned is pumped back to the original tank, via valve 10, by a pump 9.

When a motor 11 is used to rotate the magnetic filter at a high speed, the filter is washed by the centrifugal force of the rotation and the alternating magnetic field acting on the particles produced in the filter by the rotation, and a continuous or intermittent jet of washing fluid from a nozzle 13. Thus, when the ferromagnetic wires constituting the filter have the same magnetic characteristics as the magnetic particles to be removed, the degaussing effect provided by the alternating magnetic field enhances the washing effect. When the wires and particles have unlike magnetic characteristics, the washing efficiency is enhanced by the magnetic pole inversion effect provided by the alternating magnetic field. Washing efficiency is further enhanced by the intermittent jetting of the washing fluid, which prevents the formation of flow channels in the filter.

Figure 6 shows anther example of the invention, wherein one of the groups of upper and lower magnets is fixed and the other group is rotatable.

With reference to Figure 6, magnets are provided above and below the magnetic filter 2. As the washing fluid flows between the upper magnets 6a and the lower magnets 6b, high-efficiency cleaning is possible because there is nothing obstructing the flow-path.

As shown in Figure 6(C), in the upper magnets 6a and the lower magnets 6b, are arranged so that the poles of adjacent magnets are unlike. In addition, the magnets 6a and 6b are arranged so that unlike poles face each other. Provided between the magnets 6a and 6b is a filter 2 constituted of ferromagnetic small-gage wires. By producing a magnetic field in the wires, the magnetic particles are caused to adhere thereto.

With such an arrangement, when the lower magnets are rotated, the unlike polarity of the opposed

upper and lower magnets will be changed to like polarity, with south poles facing south poles and north poles facing north poles.

With such a configuration, an alternating magnetic field acting on ferromagnetic wires provided between the upper and lower magnets produces a state of apparent non-magnetism, enabling even higher-efficiency to be effected.

Figure 7 shows the washing effect obtained with the example shown in Figure 6. Namely, Figure 7(A) and 7(D) show the interior of the filter (when magnetic particles are adhering thereto). Figure 7(B) and (E) show the degaussing state of the ferromagnetic wires and the magnetic particles that accompanies the rotation of the filter and the upper magnet, during filter washing. That is, as shown in Figure 7(C), state (a) is when the magnetic parts are adhering, and during filter washing it becomes state (b) by an amount proportional to the rate at which the generated alternating magnetic field revolves, and the external magnetic field is removed.

In this state, the magnetization of the ferromagnetic wires disappears and the magnetization of the magnetic particles is reduced.

At this point, as mentioned above, high-efficiency filter washing can be effected by the centrifugal force generated by the filter rotation and the pulsed supply of washing fluid.

Figure 8 shows an example of an apparatus for the cleaning system of the invention.

Fluid containing the magnetic particles to be filtered out is delivered by a pump 8 into the apparatus. The fluid is passed through a magnetic field formed by permanent magnets 6 disposed above and below. In the course of this, a large magnetic gradient generated by a filter constituted of ferromagnetic small-gage wires causes the particles to be captured by the wires. The fluid thus cleaned is pumped back to its original tank, via valve 10, by a pump 9.

The lower magnets 6b are provided on a filter unit 12. In operation, the motor 11 is used to rotate the magnetic filter unit 12 at a high speed to produce a jet of washing fluid from a nozzle 13 for the washing.

Example 1

After rolling oil used in the cold-rolling process has been cleaned by passing it through a magnetic filter to filter out magnetic particles contained in the fluid, the filter was washed using the method of this invention.

Washing was conducted for 5 minutes at a constant fluid flow-rate of 20 liters/minute. The results are shown in Figure 9. In the figure, A and B show the results gained with the method of this invention; A is the result of the filter with respect to which both the upper and the lower magnets are fixed, and B is the result of the filter with respect to which the upper magnets are fixed and the lower magnets are rotatable.

Washing efficiency is as follows:

Washing efficiency (%) = The amount of particles discharged/the amount of particles removed.

The accompanying numeral 1 shows when the ferromagnetic small-gage wires and the particles had different magnetic characteristics, and numeral 2 shows when the magnetic characteristics were the same.

At a filter speed of 2,000 rpm the filter washing effect obtained with the method of the present invention is good, being substantially unaffected by the magnetic characteristics of the ferromagnetic small-gage wires.

Figure 10 shows the washing results obtained when washing fluid was supplied intermittently (at 20 liters/minute during actual delivery) for a washing time of 5 minutes. The results show the relationship between filter speed (rpm) and washing efficiency. The experimental conditions (A_1, A_2, B_1, B_2) are the same as in Figure 9.

These results show that the filter washing effect obtained with the method of the present invention is good. Even when compared with the results obtained using a continuous delivery of washing fluid (see Figure 9), filter washing is substantially perfect from filter speeds as low as 300 rpm.

Also, compared to when the ferromagnetic wires constituting the filter have different magnetic characteristics to the magnetic particles to be removed, when the wires and particles have the same magnetic characteristics quite a high washing efficiency can be obtained at even lower speeds (i.e., below 300 rpm).

Therefore, by giving the ferromagnetic small-gage wires that constitute the filter element magnetic characteristics that are different from those of the magnetic particles, and by also using an intermittent delivery of washing fluid, a high washing efficiency can be obtained at relatively low filter speeds and with a small amount of washing fluid, from which it can be seen that the method of the invention is advantageous in terms of both cost and washing efficiency.

Example 2

Rolling oil used in the cold-rolling process was cleaned using the method of the present invention.

Washing was conducted for 5 minutes at a washing-fluid flow-rate of 10 liters/minute and a washing filter speed of 1,300 rpm, and the quantity of steel particles that remained adhered to the magnetic filter was measured. The results are shown in Table 1.

Table 1

	Magnet location and rotation format	Particles remaining on the magnetic filter
No. 1	Rotation of upper and lower magnets	500 ppm (100 mg)
No. 2	Fixing upper magnets and rotating lower magnets	5 ppm (1 mg)
No. 3	Rotation of upper magnets and fixing of lower magnets	6 ppm (1 mg)
Partitioning the filter and providing the magnets on the partition		(1000 mg)

As can be seen from No. 1 in Table 1, washing efficiency was increased when washing was performed using a rotating filter with an alternating magnetic field produced by fixed magnets provided above and below the magnetic filter. Also, as shown by No. 2 and No. 3, washing efficiency was further increased when performed by fixing one set of magnets and generating an attraction-repellent magnetic field.

Claims

1. The method of washing a magnetic filter by removing from the magnetic filter magnetically-separated magnetic particles, comprising disposing magnets above and below the magnetic filter in the direction of rotation thereof, jetting fluid onto the magnetic filter while rotating the magnetic filter.

2. The method of washing a magnetic filter according to claim 1, comprising forming a magnetic field that is perpendicular to the direction of filter rotation, rotating the magnetic filter in an alternating magnetic field formed therein by a multiplicity of magnets arranged so that adjacent magnets have unlike polarity, and intermittently jetting the fluid into the filter.

3. A method of washing a magnetic filter according to claim 1 or 2, comprising disposing a multiplicity of magnets above and below, with the magnets arranged so that the poles of adjacent magnets are unlike, and fixing one of the upper or lower multiplicity of magnets and rotating the other multiplicity to generate an attraction-repellent magnetic field.

FIG. 1

(a)

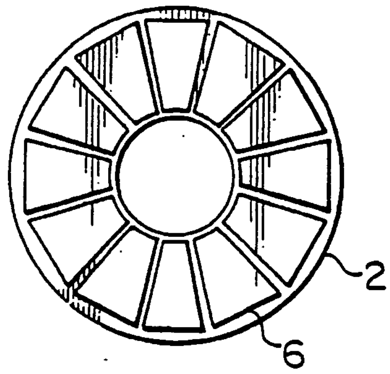


FIG. 1

(b)

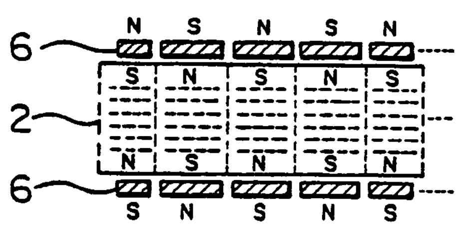


FIG. 2

(A)

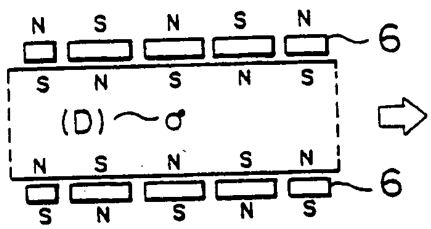


FIG. 2

(B)

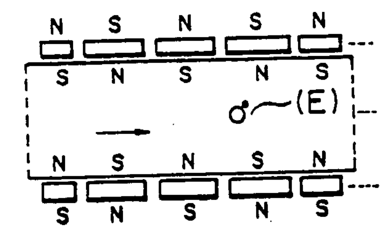


FIG. 2

(D)

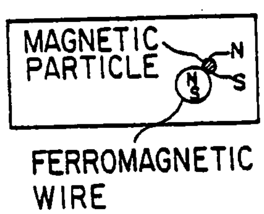


FIG. 2

(E)

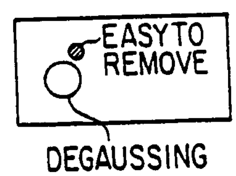


FIG. 2

(C)

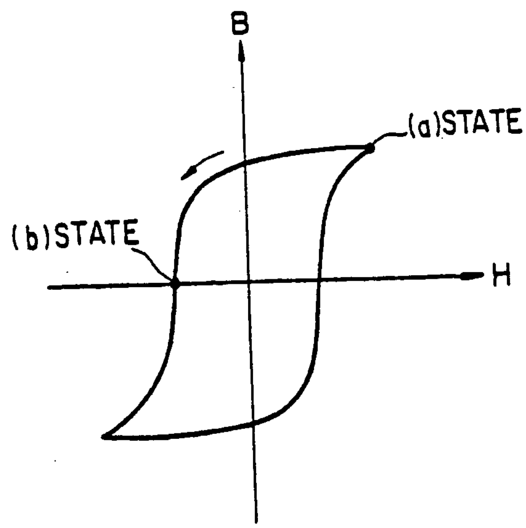


FIG. 3

(A)

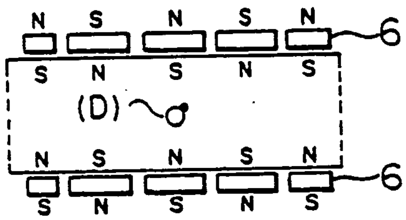


FIG. 3

(B)

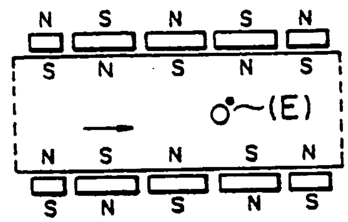


FIG. 3

(D)

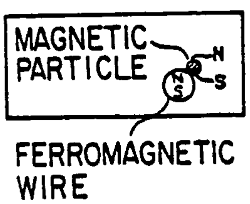


FIG. 3

(E)

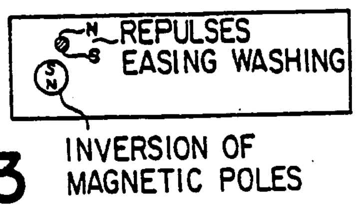


FIG. 3

(C)

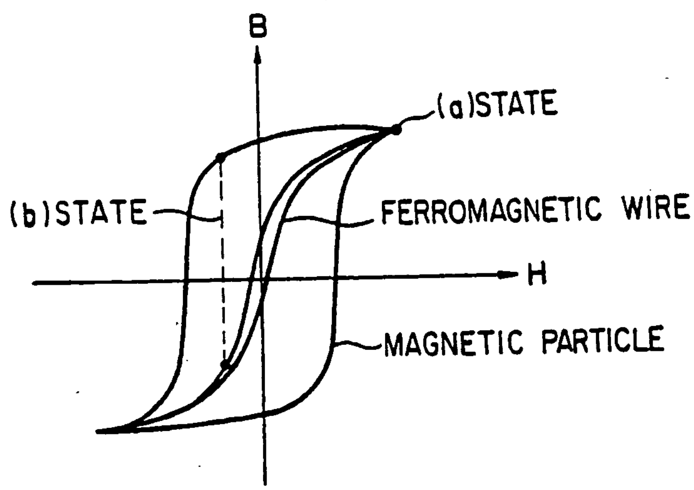


FIG. 4

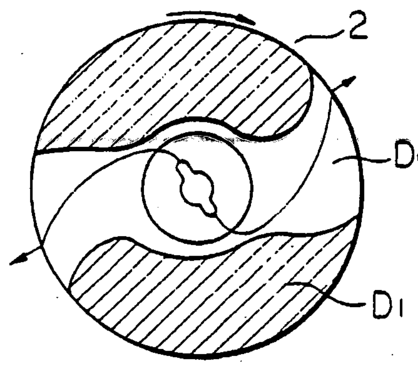


FIG. 5

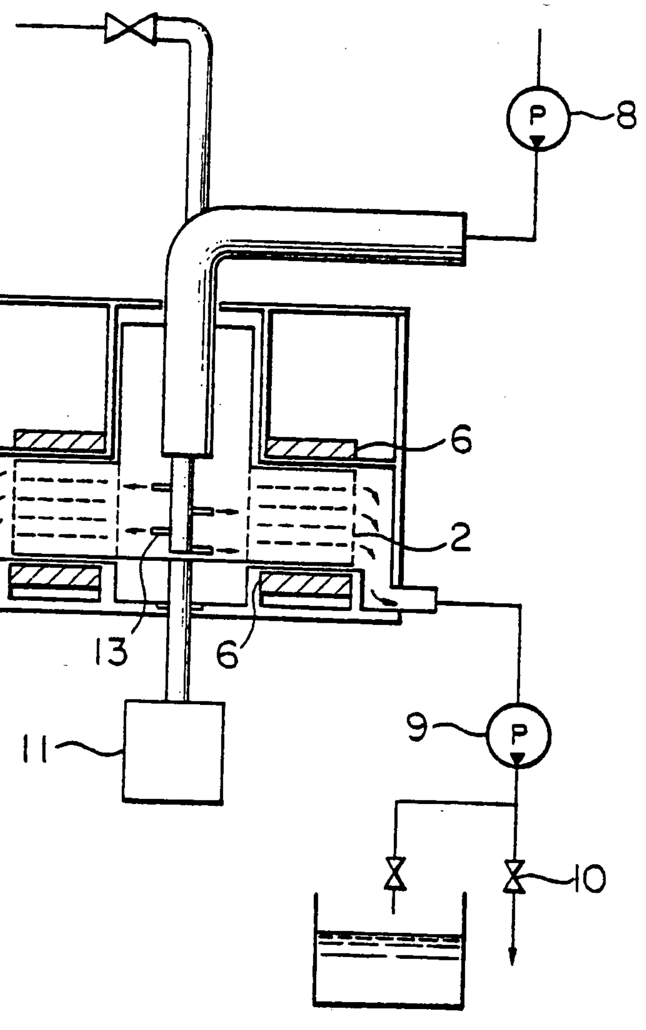


FIG. 6

(a)

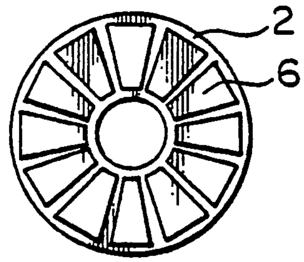


FIG. 6

(b)

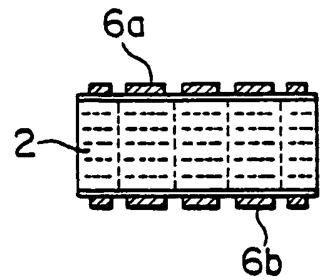


FIG. 6

(c)

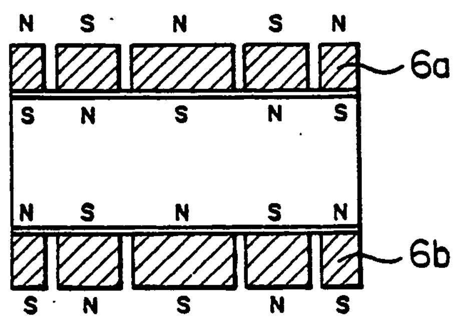


FIG. 7

(A)

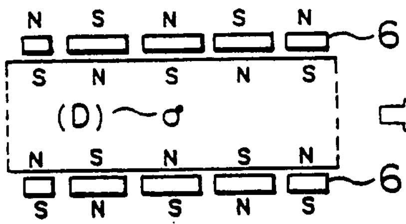


FIG. 7

(B)

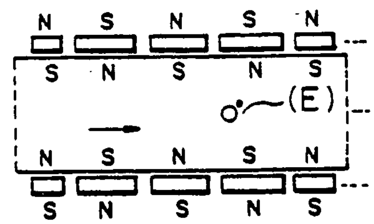


FIG. 7

(D)

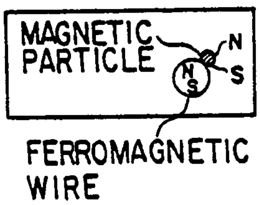


FIG. 7

(E)

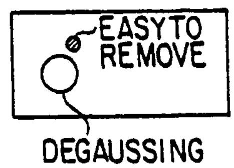


FIG. 7

(C)

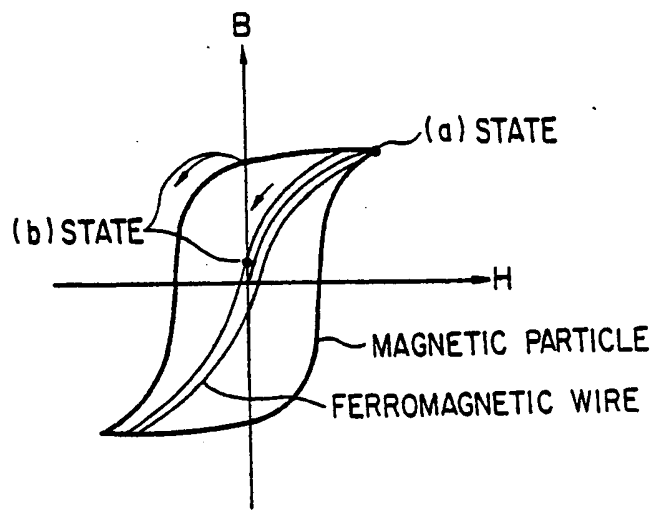


FIG. 8

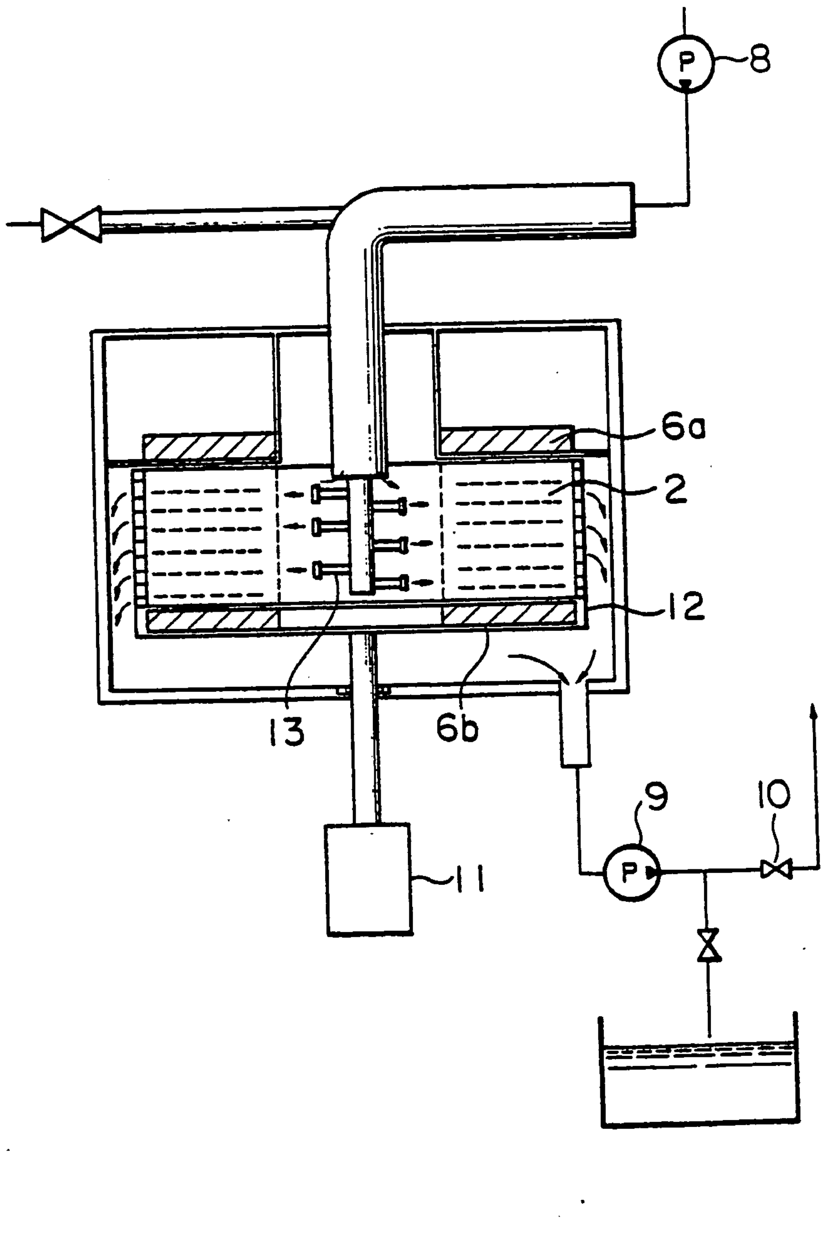


FIG. 9

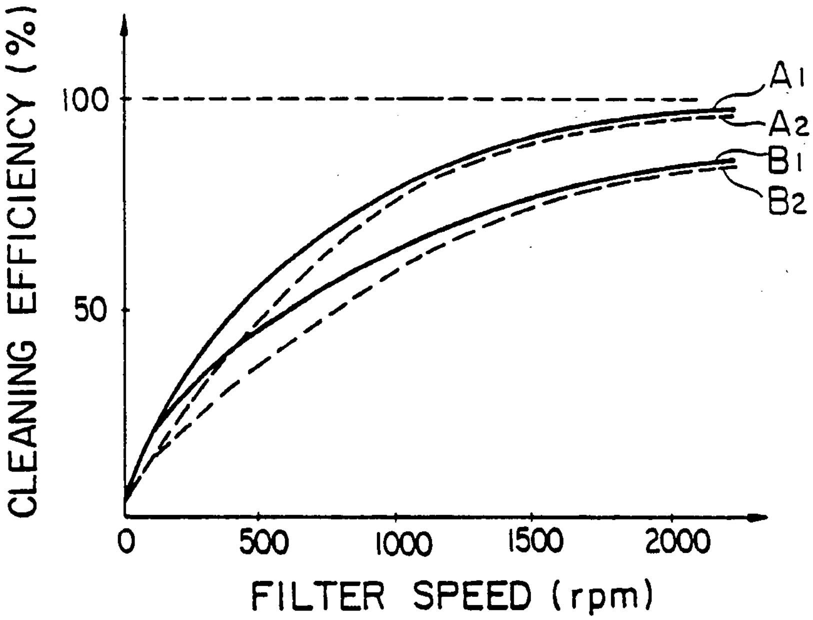

CLEANING EFFICIENCY (%)
100
50
0
500
1000
1500
2000
FILTER SPEED (rpm)
A1
A2
B1
B2

FIG. 10

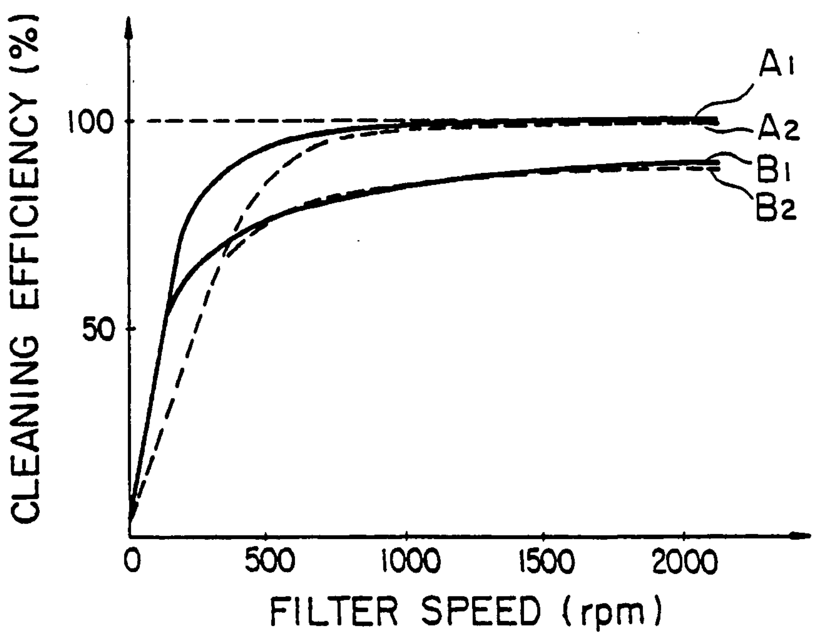

CLEANING EFFICIENCY (%)
100
50
0
500
1000
1500
2000
FILTER SPEED (rpm)
A1
A2
B1
B2

FIG. 11

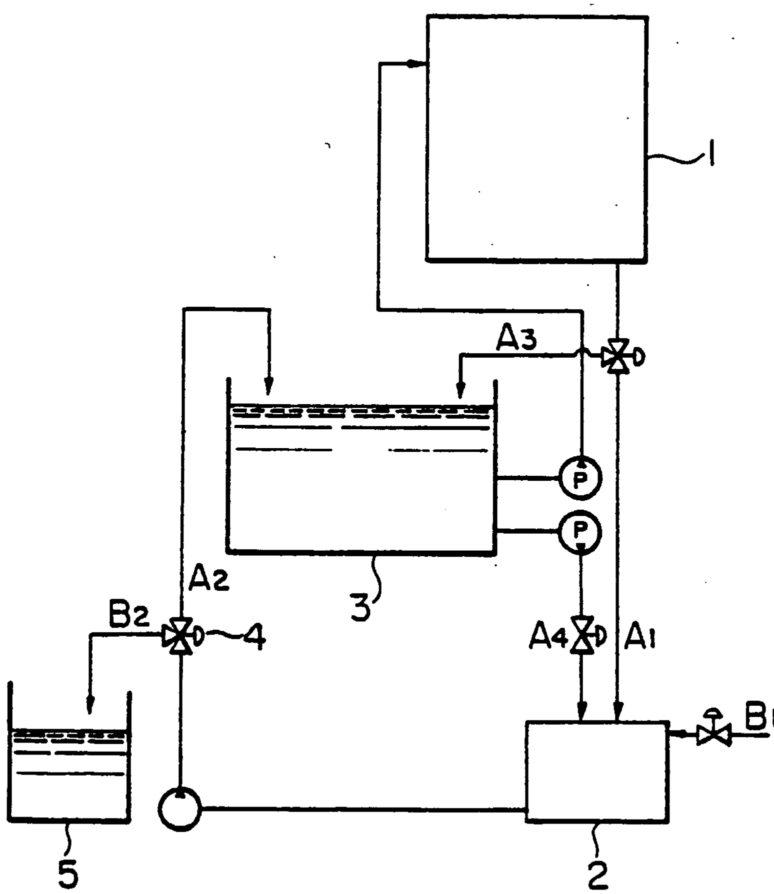


FIG. 12
(PRIOR ART)
(a)

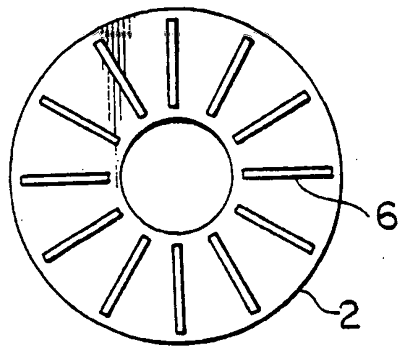


FIG. 12
(PRIOR ART)
(b)

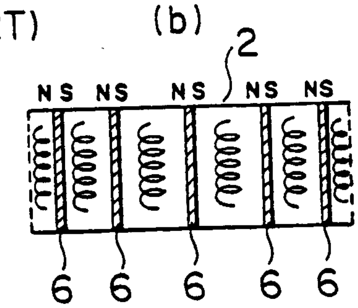
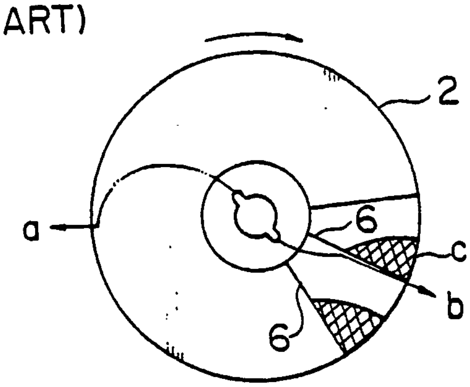


FIG. 13
(PRIOR ART)



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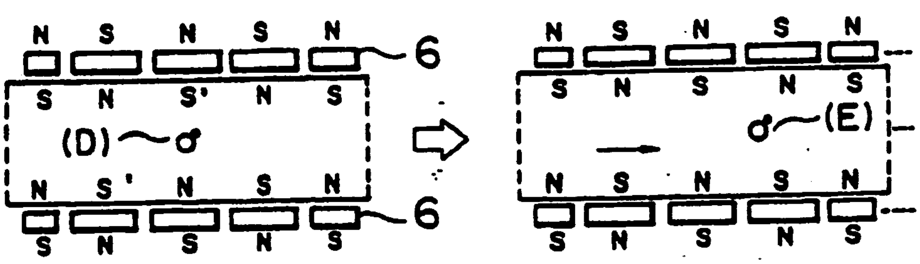
(54) **Method of washing off magnetically separated particles.**

(57) A method of removing magnetically-separated magnetic particles adhering to a magnetic filter. Sets of radially-arranged magnets are provided above and below, with adjacent magnets having unlike poles. The filter is located in an alternating magnetic field formed by the magnets. The filter is washed by directing a jet of fluid at it while magnets, or filter, is being rotated.

FIG. 2 (A)   FIG. 2 (B)



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EUROPEAN SEARCH REPORT

Application Number

EP 88 11 9871

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	SU-A- 706 126 (GIPROMASHOBOGASHIE) * Whole document * ---	1,2	B 03 C 1/00
A	US-A-2 508 666 (S.G. FRANTZ) * Claim 1; figure 1 * -----	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

B 03 C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	26-03-1990	DECANNIERE L.J.

CATEGORY OF CITED DOCUMENTS

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